AP Chemistry – Chapter 4: Chemical Equations and Stoichiometry Supplemental Worksheet

Name: _____ Date: _____ Period: _____

1. Oil paintings in which "white lead" has been used can be blackened by reaction with H_2S from air pollution or from the glaze over the painting itself. The blackening comes from the formation of lead sulfide, which may be cleaned off by washing with hydrogen peroxide, H_2O_2. The reaction for the cleaning process is
   $PbS\ (black\ solid) + 4\ H_2O_{2(aq)} \rightarrow PbSO_{4(s)} + 4\ H_2O_{(l)}$
   a. How many grams of H_2O_2 must be used to clean off 0.24 g of PbS?
   b. If 0.072 g of H_2O form in the reaction, how many grams of $PbSO_4$ must also have been formed?

2. Methyl alcohol, CH_3OH, is a clean-burning, easily handled fuel. It can be made by the direct reaction of CO and H_2 (obtained from coal and water).
   $CO_{(g)} + 2\ H_{2(g)} \rightarrow CH_3OH_{(l)}$
   Assume you start with 12.0g of H_2 and 74.5g of CO;
   a. Which of the reactants is in excess?
   b. Which is the limiting reagent?
   c. What mass (in grams) of the excess reagent is left after the reaction is complete?
   d. How many grams of methyl alcohol can be obtained theoretically?

3. Zinc and chlorine react directly to give zinc chloride.
   $Zn_{(s)} + Cl_{2(g)} \rightarrow ZnCl_{2(s)}$
   If you begin with 1.00 mole of zinc and excess Cl_2, what is the theoretical yield of $ZnCl_2$ in grams? If you isolate 115g of $ZnCl_2$, what is the percent yield of the metal chloride?

4. Butane, which contains only C and H, is a commonly used fuel in camping stoves. To determine the formula of butane, assume you burn 0.580g of the gas and obtain 1.760g of CO_2 and 0.900g of H_2O. What is the empirical formula of butane?

5. Metal carbonates give the appropriate metal oxide and CO_2 when heated. For example,
   $CaCO_{3(s)} \rightarrow CaO_{(s)} + CO_{2(g)}$
   Limestone is mostly calcium carbonate, $CaCO_3$, but other minerals are usually present as well. Assume a 1.605g sample of limestone is heated and decomposed completely to CaO, 0.657 g of CO_2, and an inert residue. What is the weight percentage of $CaCO_3$ in the limestone sample?

6. Complete combustion of 0.255g of an alcohol produces 0.561 grams of CO_2 and 0.306 grams of H_2O. Calculate its
   a. Mass percent composition
   b. Empirical formula

7. Balance the following equations:

   $PCl_5 + H_2O \rightarrow H_3PO_4 + HCl$
   $CaO + P_4O_{10} \rightarrow Ca_3(PO_4)_2$
   $Ba(NO_3)_2 + Al_2(SO_4)_3 \rightarrow BaSO_4 + Al(NO_3)_3$
   $NaHCO_3 + H_2SO_4 \rightarrow Na_2SO_4 + H_2O + CO_2$
   $C_4H_{10} + O_2 \rightarrow CO_2 + H_2O$

8. Write a plausible chemical equation for the combustion of liquid triethylene glycol in an abundant supply of oxygen gas. Triethylene glycol is 47.99% C, 9.40% H, and 42.62% O by mass and has a molecular mass of 150.2u.

9. One way to change the iron mineral, Fe_2O_3, into metallic iron is to heat it with hydrogen.
   $Fe_2O_3 + 3H_2 \rightarrow 2Fe + 3H_2O$
   a. How many moles of iron are made from 20mol of Fe_2O_3?
   b. How many moles of H_2 are needed to make 24mol of Fe?
   c. If 90mol of H_2O forms, how many grams of Fe_2O_3 were used up?

10. Phosphorus pentachloride reacts with water to give phosphoric acid and hydrochloric acid. In one experiment, 0.360mol of phosphorus pentachloride was slowly added to 2.88mol of water.
    a. Which reactant, if either, was the limiting reactant?
    b. Calculate the theoretical yields (in moles) of phosphoric acid and hydrochloric acid.

11. Aluminum sulfate can be made by the following reaction
    $2AlCl_{3(aq)} + 3H_2SO_{4(aq)} \rightarrow Al_2(SO_4)_{3(aq)} + 6HCl_{(aq)}$
    Aluminum sulfate is quite soluble in water, so to isolate it the solution has to be evaporated to dryness. This drives off the volatile HCl, but the residual solid has to be heated to a little over 200°C to drive off all of the water. In one experiment, 25.00g of $AlCl_3$ was used.
    a. How many grams of H_2SO_4 are needed?
    b. After the procedure, 28.36g of pure aluminum sulfate was isolated. Calculate the percent yield of the reaction.